C H A P T E R 9 . 2

Standard for Constructed Stormwater Wetlands

Definition

Constructed stormwater wetlands are wetland systems designed to maximize the removal of pollutants from stormwater runoff through settling and both uptake and filtering by vegetation. Constructed stormwater wetlands temporarily store runoff in relatively shallow pools that support conditions suitable for the growth of wetland plants. The adopted removal rate for Constructed Stormwater Wetlands is 90 percent.

Purpose

Constructed stormwater wetlands are used to remove a wide range of stormwater pollutants from land development sites as well as provide wildlife habitat and aesthetic features. Constructed stormwater wetlands can also be used to reduce peak runoff rates when designed as a multi-stage, multi-function facility.

Conditions Where Practice Applies

Constructed stormwater wetlands require sufficient drainage areas and dry weather base flows to function properly. The minimum drainage area to a constructed stormwater wetland is 10 acres to 25 acres depending on the type of wetland. See text below for details.

Constructed stormwater wetlands should not be located within natural wetland areas, since they will typically not have the full range of ecological functions of natural wetlands. While providing some habitat and aesthetic values, constructed stormwater wetlands are designed primarily for pollutant removal and erosion and flood control.

It is important to note that a constructed stormwater wetland must be able to maintain its permanent pool level. If the soil at the wetland site is not sufficiently impermeable to prevent excessive seepage, construction of an impermeable liner or other soil modifications will be necessary.

Design Criteria

The basic design parameters for a constructed stormwater wetland are the storage volumes within its various zones. In general, the total volume within these zones must be equal to the design runoff volume. An exception to this requirement is made for an Extended Detention Wetland. In addition, the character, diversity, and hardiness of the wetland vegetation must be sufficient to provide adequate pollutant removal. Details of these and other design parameters are presented below.

Constructed stormwater wetlands typically consist of three zones: pool, marsh, and semi-wet. Depending upon their relative size and the normal or dry weather depth of standing water, the pool zone may be further characterized as either a pond, micropond, or forebay. Similarly, the marsh zone may be further characterized as either high or low marsh based again upon the normal standing water depth in each.

Depending on the presence and relative storage volume of the pool, marsh, and semi-wet zones, a constructed stormwater wetland may be considered to be one of three types: pond wetland, marsh wetland, or extended detention wetland. As described in detail below, a pond wetland consists primarily of a relatively deep pool with a smaller marsh zone outside it. Conversely, a marsh wetland has a greater area of marsh than pool zone. Finally, an extended detention wetland consists of both pool and marsh zones within an extended detention basin.

Table 9.2-1 below presents pertinent design criteria for each type of constructed stormwater wetland. As shown in the table, each type (i.e., pond, marsh, and extended detention wetland) allocates different percentages of the total Stormwater Quality Storm runoff volume to its pool, marsh, and semi-wet zones. In a pond wetland, this volume is distributed 70 percent to 30 percent between the pool and marsh zones. Conversely, in a marsh wetland, the total runoff volume is distributed 30 percent to 70 percent between the pool and marsh zones. Both of these zone volumes are based on their normal standing water level.

However, in an extended detention wetland, only 50 percent of the Stormwater Quality Storm runoff volume is allocated to the pool and wetland zones, with 40 percent of this amount (or 20 percent of the total Stormwater Quality Storm runoff volume) provided in the pool zone and 60 percent (or 30 percent of the total runoff volume) provided in the marsh zone. The remaining 50 percent of the Stormwater Quality Storm runoff volume is provided in the wetland's semi-wet zone above the normal standing water level, where it is temporarily stored and slowly released similar to an extended detention basin. As noted in Table 9.2-1, the detention time in the semi-wet zone of an extended detention wetland must meet the same detention time requirements as an extended detention basin. These requirements are presented in Section 9.4 – Extended Detention Basins. The minimum diameter of any outlet orifice in all wetland types is 2.5 inches.

The components of a typical stormwater wetland are illustrated in Figure 9.2-1. Pertinent design criteria for each component are presented in Table 9.2-1. Additional details of each type of constructed stormwater wetland and the components of each are described below.

A. Pool Zone

Pools generally have standing water depths of 2 to 6 feet and primarily support submerged and floating vegetation. Due to their depths, support for emergent vegetation is normally limited. As noted above, the pool zone may consist of a pond, micropond, and/or forebay depending on their relative sizes and depths. Descriptions of these pool types are presented below:

1. Pond

Ponds generally have standing water depths of 4 to 6 feet and, depending on the type, may comprise the largest portion of a constructed stormwater wetland. Ponds provide for the majority of particulate settling in a constructed stormwater wetland.

2. Micropond

In general, a micropond also has a standing water depth of 4 to 6 feet, but is smaller in surface area than a standard pond (see 1 above). A micropond is normally located immediately upstream of the outlet from a constructed stormwater wetland. At that location, it both protects the outlet from clogging by debris and provides some degree of particulate settling. Since a micropond does not provide the same degree of settling as a standard pond, it is normally combined with a larger area of marsh than a standard pond.

3. Forebay

Forebays are located at points of concentrated inflow to constructed stormwater wetlands. As such, they serve as pretreatment measures by removing coarser sediments, trash, and debris. They typically have normal standing water depths of 2 to 4 feet.

B. Marsh Zone

Marshes have shallower standing water depths than ponds, generally ranging from 6 to 18 inches. At such depths, they primarily support emergent wetland vegetation. As noted above, a marsh is classified as either a high or low marsh depending on the exact depth of standing water.

1. Low Marsh

A low marsh has a standing water depth of 6 to 18 inches. It is suitable for the growth of several emergent wetland plant species.

2. High Marsh

A high marsh has a maximum standing water depth of 6 inches. Due to its shallower depth, it will have a higher standing water surface area to volume ratio than a low marsh. It will normally support a greater density and diversity of emergent wetland species than a low marsh.

C. Semi-Wet Zone

The semi-wet zone in a constructed stormwater wetland is located above the pool and marsh zones and is inundated only during storm events. As a result, it can support both wetland and upland plants.

Figure 9.2-1: Constructed Stormwater Wetland Components

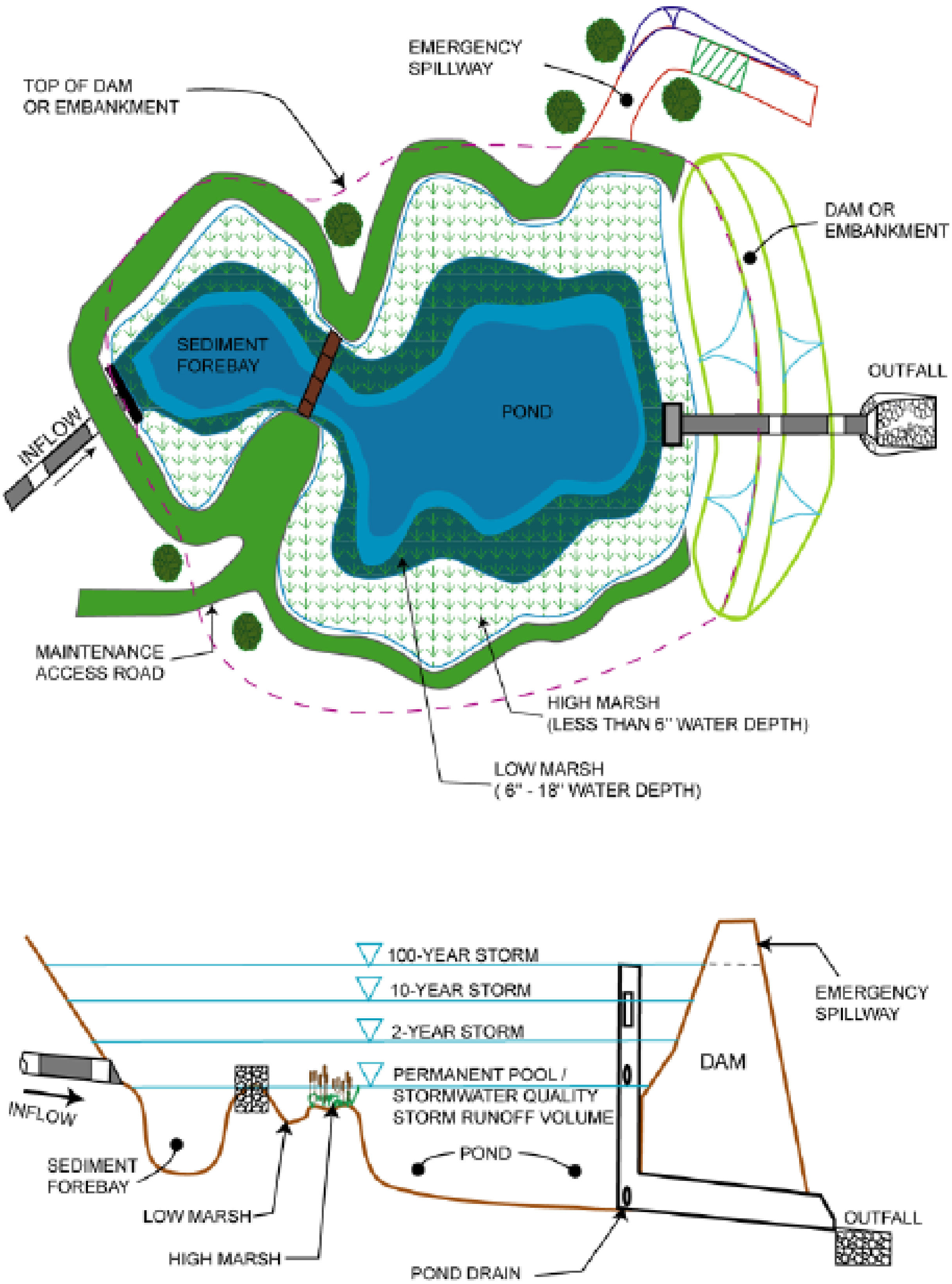

Table 9.2–1: Design Criteria for Constructed Stormwater Wetlands

Wetland Design Feature	Type of Constructed Stormwater Wetland		
	Pond	Marsh	Extended Detention
Minimum Drainage Area (Acres)	25	25	10
Minimum Length to Width Ratio	1:1	1:1	1:1
Allocation of Stormwater Quality Storm Runoff Volume (Pool / Marsh / Semi-Wet*)	70 / 30 / 0	30 / 70 / 0	20 / 30 / 50*
Pool Volume (Forebay / Micropond / Pond)	10 / 0 / 60	10 / 20 / 0	10 / 10 / 0
Marsh Volume (Low / High)	20 / 10	45 / 25	20 / 10
Sediment Removal Frequency (Years)	10	2 to 5	2 to 5
Outlet Configuration	Reverse-Slope Pipe or Broad Crested Weir	Reverse-Slope Pipe or Broad Crested Weir	Reverse-Slope Pipe or Broad Crested Weir

* In an Extended Detention Wetland, 50 percent of the Stormwater Quality Storm runoff volume is temporarily stored in the semi-wet zone. Release of this volume must meet the detention time requirements for Extended Detention Basins (see text above and Section 9.4).

D. Types of Constructed Stormwater Wetlands

1. Pond Wetlands

Pond wetlands consist primarily of ponds with standing water depths ranging from 4 to 6 feet in normal or dry weather conditions. Pond wetlands utilize at least one pond component in conjunction with high and low marshes. The pond is typically the component that provides for the majority of particulate pollutant removal. This removal is augmented by a forebay, which also reduces the velocity of the runoff entering the wetland. The marsh zones provide additional treatment of the runoff, particularly for soluble pollutants.

Pond wetlands require less site area than marsh wetlands and generally achieve a higher pollutant removal rate than the other types of constructed stormwater wetland. See Table 9.2-1 for the relative Stormwater Quality Storm runoff volumes to be provided in each wetland component.

2. Marsh Wetlands

Marsh wetlands consist primarily of marsh zones with standing water depths ranging up to 18 inches during normal or dry weather conditions. These zones are further configured as low and high marsh components as described above. The remainder of the Stormwater Quality Storm runoff volume storage is provided by a micropond. See Table 9.2-1 for the relative Stormwater Quality Storm runoff volumes to be provided in each wetland component.

Marsh wetlands should be designed with sinuous pathways to increase retention time and contact area. Marsh wetlands require greater site area than other types of constructed stormwater wetlands. In order to have the base and/or groundwater flow rate necessary to support emergent plants and minimize mosquito breeding, marsh wetlands may also require greater drainage areas than the other types. This is due to the relatively larger area of a marsh wetland as compared with either a pond or extended detention wetland. This larger area requires greater rates of normal inflow to generate the necessary flow velocities and volume changeover rates.

3. Extended Detention Wetlands

Unlike pond and marsh wetlands, an extended detention wetland temporarily stores a portion of the Stormwater Quality Storm runoff volume in the semi-wet zone above its normal standing water level. This temporary runoff storage, which must be slowly released in a manner similar to an extended detention basin, allows the use of relatively smaller pool and marsh zones. As a result, extended detention wetlands require less site area than pond or marsh wetlands. See Table 9.2-1 for the relative Stormwater Quality Storm runoff volumes to be provided in each wetland component. See Section 9.4 – Extended Detention Basins for the required detention times for the temporary semi-wet zone storage.

Due to the use of the semi-wet zone, water levels in an extended detention wetland will also increase more during storm events than pond or marsh wetlands. Therefore, the area of wetland vegetation in an extended detention wetland can expand beyond the normal standing water limits occupied by the pool and marsh zones. Wetland plants that tolerate intermittent flooding and dry periods should be selected for these areas.

E. Drainage Area

The minimum drainage area to a constructed stormwater wetland varies from 10 to 25 acres depending on the type of constructed stormwater wetland. See Table 1 for details. See also D. Types of Constructed Stormwater Wetlands above for a discussion of base and groundwater flow needs.

F. Overflows

All constructed stormwater wetlands must be able to convey overflows to downstream drainage systems in a safe and stable manner. Constructed stormwater wetlands classified as dams under the NJDEP Dam Safety Standards (NJAC 7:20) must also meet the overflow requirements of these Standards.

G. Tailwater

The design of all hydraulic outlets must consider any significant tailwater effects of downstream waterways or facilities. This includes instances where the lowest invert in the outlet or overflow structure is below the Flood Hazard Area Design Flood Elevation of a receiving stream.

H. On-Line and Off-Line Systems

Constructed stormwater wetlands may be constructed on-line or off-line. On-line systems receive upstream runoff from all storms, providing runoff treatment for the Stormwater Quality Storm and conveying the runoff from larger storms through an outlet or overflow. Multi-purpose on-line systems also store and attenuate these larger storms to provide runoff quantity control as well. In such systems, the invert of the lowest stormwater quantity control outlet is set at or above the normal permanent pool level. In off-line constructed stormwater wetlands, most or all of the runoff from storms larger than the Stormwater Quality Storm are diverted past the system. In selecting an off-line design, the potential effects on wetland vegetation and ecology of diverting higher volume runoff events should be considered.

I. Safety Ledges

Safety ledges must be constructed on the slopes of all constructed stormwater wetlands with a permanent pool of water deeper than three feet. Two ledges must be constructed, each 4 to 6 feet in width. The first or upper ledge must be located between 1 and 1.5 feet above the normal standing water level. The second or lower ledge must be located approximately 2.5 feet below the normal standing water level.

Operation and Maintenance

Effective constructed stormwater wetland performance requires proper operation and regular maintenance. Chapter 8 provides information and requirements for preparing an Operation and Maintenance Plan for stormwater management facilities, including constructed stormwater wetlands. Specific operation and maintenance requirements for bioretention systems are presented below. These requirements must be included in the system's Operations and Maintenance Plan.

A. General Maintenance

All constructed stormwater wetland components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding one inch of rainfall. Such components may include forebays, bottoms, trash racks, outlet structures, and riprap or gabion aprons.

Disposal of debris and trash should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

The types and distribution of the dominant wetlands plants must be assessed based on the planted wetland species, volunteer wetland species, and signs the volunteer species are replacing planting species. The vegetative areas shall be maintained in order to maintain health in accordance with the inspection.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health should not compromise the intended purpose of the constructed stormwater wetland. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The Operation and Maintenance Plan must indicate the approximate time that the system would normally take to drain the Stormwater Quality Storm runoff and return the various pools to their normal standing water levels. This drain or drawdown time should then be used to evaluate the system's actual performance. If significant increases or decreases in the drain time are observed, the wetland's outlet structure, forebay, and groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the wetland.

Considerations

Constructed stormwater wetlands are limited by a number of site constraints, including soil types, depth to groundwater, contributing drainage area, and available land area at site.

A. Construction

The following minimum setback requirements should apply to stormwater wetland installations:

Distance from a septic system leach field = 50 feet.

Distance from a septic system tank = 25 feet.

Distance from a property line = 10 feet.

Distance from a private well = 50 feet.

Schueler (1992) lists a seven-step process for preparation of the wetland bed prior to planting:

1. Prepare final pondscaping and grading plans for the stormwater wetland. At this time order wetland plant stock from aquatic nurseries.
2. Once the stormwater wetland volume has been excavated, the wetland should be graded to create the major internal features (pool, safety ledge, marshes, etc.).
3. After the mulch or topsoil has been added, the stormwater wetland needs to be graded to its final elevations. All wetland features above the normal pool should be stabilized temporarily.
4. After grading to final elevations, the pond drain should be closed and the pool allowed to fill. Usually nothing should be done to the stormwater wetland for six to nine months or until the next planting season. A good design recommendation is to evaluate the wetland elevations during a standing period of approximately six months. During this time the stormwater wetland can experience storm flows and inundation, so that it can be determined where the pondscaping zones are located and whether the final grade and microtopography will persist overtime.
5. Before planting, the stormwater wetland depths should be measured to the nearest inch to confirm planting depth. The pondscape plan may be modified at this time to reflect altered depths or availability of plant stock.
6. Erosion controls should be strictly applied during the standing and planting periods. All vegetated areas above the normal pool elevation should be stabilized during the standing period, usually with hydroseeding.
7. The stormwater wetland should be de-watered at least three days before planting since a dry wetland is easier to plant than a wet one.

Topsoil and/or wetland mulch is added to the stormwater wetland excavation. Since deep subsoils often lack the nutrients and organic matter to support vigorous plant growth, the addition of mulch or topsoil is important. If it is available, wetland mulch is preferable to topsoil.

B. Site Constraints

Medium-fine texture soils (such as loams and silt loams) are best to establish vegetation, retain surface water, permit groundwater discharge, and capture pollutants. At sites where infiltration is too rapid to sustain permanent soil saturation, an impermeable liner may be required. Where the potential for groundwater contamination is high, such as runoff from sites with a high potential pollutant load, the use of liners. At sites where bedrock is close to the surface, high excavation costs may make constructed stormwater wetlands infeasible.

C. Design Approach

A pondscaping plan should be developed for each stormwater wetland. This plan should include hydrological calculations (or water budget), a wetland design and configuration, elevations and grades, a site/soil analysis, and estimated depth zones. The plan should also contain the location, quantity, and propagation methods for the stormwater wetland plants. Site preparation requirements, maintenance requirements and a maintenance schedule are also necessary components of the plan.

The water budget should demonstrate that there would be a continuous supply of water to sustain the stormwater wetland. The water budget should be developed during site selection and checked after preliminary site design. Drying periods of longer than two months have been shown to adversely effect plant community richness, so the water balance should confirm that drying will not exceed two months.

D. Effectiveness

A review of the existing performance data indicates that the removal efficiencies of constructed stormwater wetlands are slightly higher than those of conventional pond systems, e.g. as wet ponds or dry extended detention ponds. Of the three designs described above, the pond/wetland system has shown the most reliable terms of overall performance.

Studies have also indicated that removal efficiencies of constructed stormwater wetlands decline if they are covered by ice or receive snow melt. Performance also declines during the non-growing season and during the fall when the vegetation dies back. Until vegetation is well established, pollutant removal efficiencies may be lower than expected.

Recommendations

A. Vegetation

Establishment and maintenance of the wetland vegetation is an important consideration when planning a stormwater wetland. The following is a list of recommendations (Horner et al, 1994) for creating constructed stormwater wetlands:

> In selecting plants, consider the prospects for success more than selection of native species. Since diversification will occur naturally, use a minimum of adaptable species. Give priority to perennial species that establish rapidly. Select species adaptable to the broadest ranges of depth, frequency and duration of inundation (hydroperiod). Give priority to species that have already been used successfully in constructed stormwater wetlands and that are commercially available. Match site conditions to the environmental requirements of plant selections. Avoid using only species that are foraged by the wildlife expected on site.
>
> Establishment of woody species should follow herbaceous species. Add vegetation that will achieve other objectives, in addition to pollution control. Monoculture planting should be avoided due to

increased risk of loss from pests and disease. When possible field collected plants should be used in lieu of nursery plants. Plants collected from the field have already adapted and are acclimated to the region. These plants generally require less care than greenhouse plants. If nursery plants are used they should be obtained locally, or from an area with similar climatic conditions as the eco-region of the constructed wetland. Alternating plant species with varying root depths have a greater opportunity of pollutant removal.

Stormwater wetland vegetation development can also be enhanced through the natural recruitment of species from nearby wetland sites. However, transplanting wetland vegetation is still the most reliable method of propagating stormwater wetland vegetation, and it provides cover quickly. Plants are commercially available through wetland plant nurseries.

The plant community will develop best when the soils are enriched with plant roots, rhizomes, and seed banks. Use of wetlands mulch enhances the diversity of the plant community and speeds establishment. Wetlands mulch is hydric soil that contains vegetative plant material. The upper 6 inches of donor soil should be obtained at the end of the growing season, and kept moist until installation. Drawbacks to using constructed stormwater wetlands mulch are its unpredictable content.

During the initial planting precautions should be undertaken to prevent and prohibit animals from grazing until pl ant communities are well established. Such precautions could be deer fencing, muskrat trapping, planting after seasonal bird migrations or attracting birds of prey and bats to control nutria populations

B. Water Budget

The water budget should demonstrate that there will be a continuous supply of water to sustain the stormwater wetland. The water budget should demonstrate that the water supply to the stormwater wetland is greater than the expected loss rate. As discussed above, drying periods of longer than two months have been shown to adversely affect plan community richness, so the water balance should confirm that drying will not exceed two months (Schueler 1992).

C. Wetlands Area

The constructed wetlands should have a minimum surface area in relation to the contributing watershed area. The reliability of pollutant removal tends to increase as the stormwater wetland to watershed ratio increases, although this relationship is not always consistent. Above ground berms or high marsh wedges should be placed at approximately 50 foot intervals, at right angles to the direction of the flow to increase the dry weather flow path within the stormwater wetland.

D. Outlet Configuration

A hooded outlet is recommended with an invert or crest elevation at least one foot below the normal pool surface.

A bottom drain pipe with an inverted elbow to prevent sediment clogging should be installed for complete draining of the constructed stormwater wetland for emergency purposes or routine maintenance. Both the outlet pipe and the bottom drain pipe should be fitted with adjustable valves at the outlet ends to regulate flows. Spillways should be designed in conformance with the state regulations and criteria for Dam Safety.

References under review.